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(54) **High-frequency heating appliance**

(57) A high-frequency heating appliance comprises a heating chamber (2, Fig. 2) waveguide (14, Fig. 2) for feeding high-frequency energy from a high-frequency oscillator (8, Fig. 2) to the chamber, and a rotary antenna 15 for microwave-wise coupling of the waveguide with the chamber. The antenna 15 comprises a vertical portion 17 substantially perpendicular to a top wall (16, Fig. 2) of the chamber and a horizontal portion 18 which is shaped as a substantially triangular plane and is connected to the vertical portion 17 in the region of an apex of the triangle. The sum of the length of a perpendicular line drawn from the connection between the vertical and horizontal portions to the side of the triangle opposite the connection and the length of a part of the vertical portion projecting into the chamber is an integral multiple or approximately one-half of the wavelength used.

FIG. 3

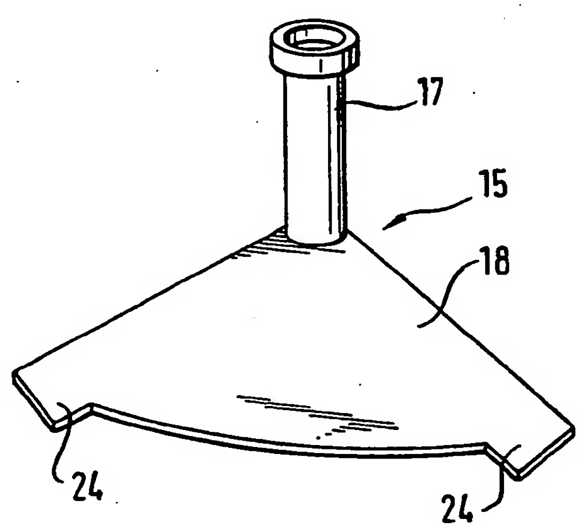

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FIG. 1

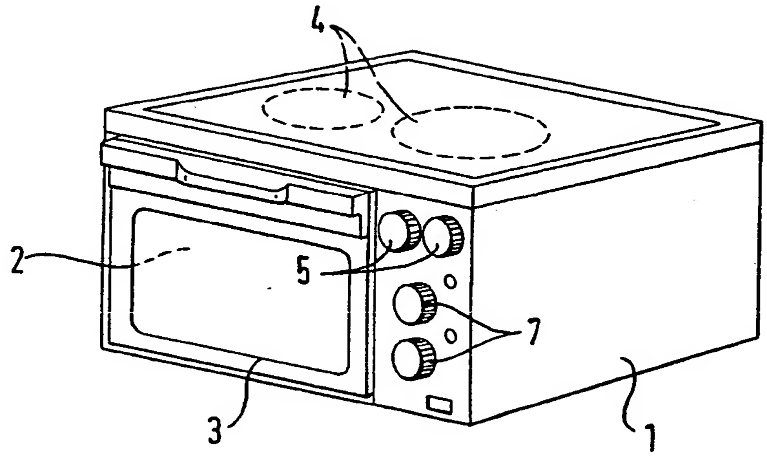

FIG. 2

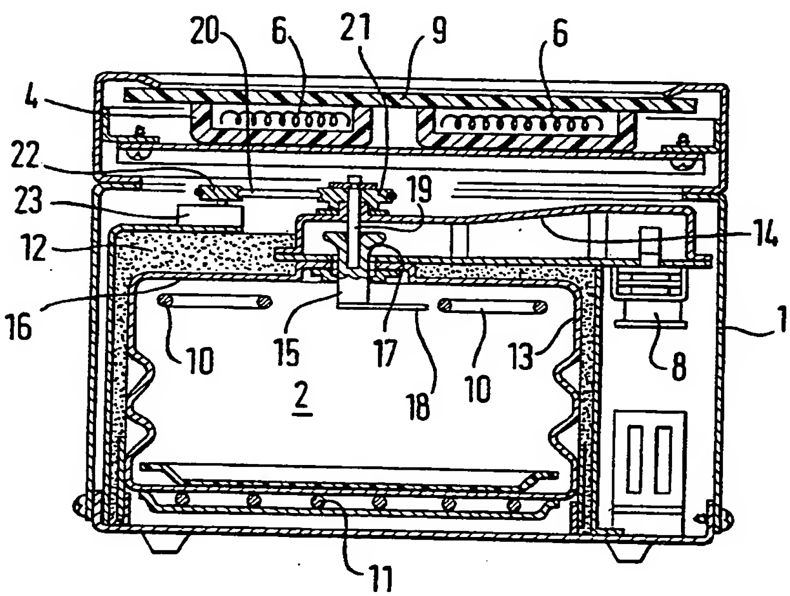

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FIG. 3

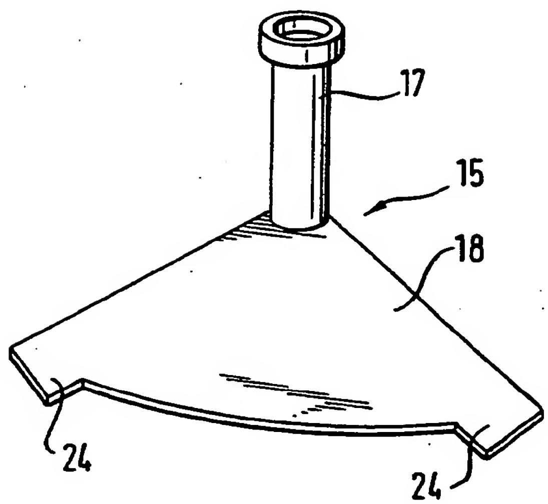


FIG. 4a

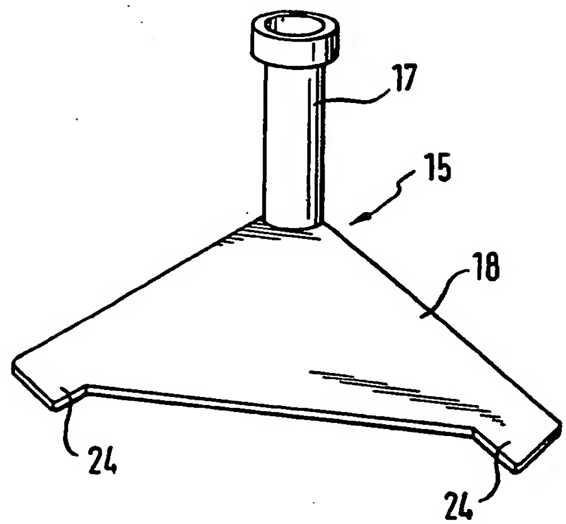


FIG. 5

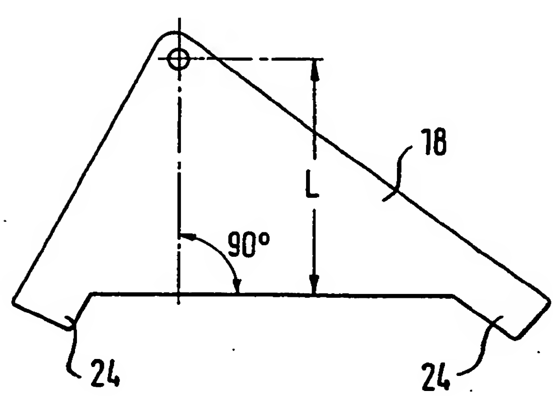
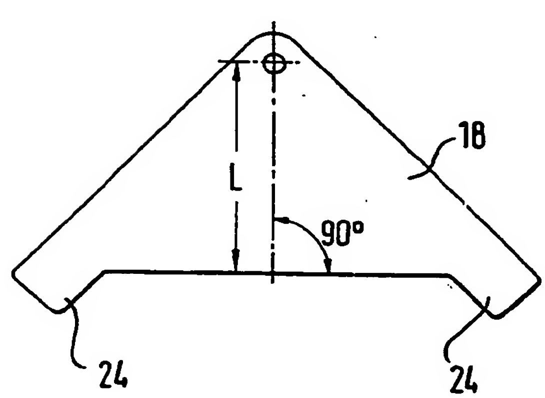


FIG. 4b



SPECIFICATION

High-frequency heating appliance

The present invention relates to a high-frequency heating appliance.

In the microwave oven, which is one of the conventional high-frequency heating appliances, the uniformity of distribution of the high-frequency energy fed into the heating chamber has been improved by installing a stirrer fan for stirring the high-frequency waves in the heating chamber, by turning a platform on which a heating load is positioned, or by installing a rotatable electric wave radiator, which is an antennae. Of these methods, the method using a rotary antenna has been adopted in many microwave ovens for household use because there can be provided a large effective free space in the heating chamber. However, when such a rotary antenna is installed in the upper portion of the heating chamber, the heating characteristic of heating a heating load in the chamber with the electromagnetic wave radiated from the antenna is not solely dependent on the antenna but dependent on the combination of the antenna with the size and shape of the heating chamber. Thus, there is no antenna that can be used commonly for various heating chamber conditions. It is thus necessary to design an optimum antenna for each particular set of heating chamber conditions. Heretofore, a number of propositions have been made with respect to the shape of rotary antennae and the energy feeding method using a rotary antenna, but as far as rotary antennae in use up to now are concerned, they have been found to have a number of disadvantages. Thus, the heating in the central zone of the heating chamber is not uniform and if, for example, the high-frequency waves are radiated to a plurality of chilled shao-mai in the central zone of the heating chamber, the temperature of the shao-mai in the centre is far lower than the temperature of those located around it. In the case of a fried egg, the peripheral portion of the egg is overheated while the central portion is still raw.

It would thus be desirable to provide a high-frequency heating appliance which overcome the above-mentioned disadvantages of the prior art appliances and is capable of performing dielectric heating of a heating load placed in a heating chamber.

According to the present invention there is provided a high-frequency heating appliance comprising a heating chamber, a waveguide for feeding high-frequency energy of a given wavelength from a high-frequency oscillator to the chamber, and a rotary antenna operable to radiate such energy in the chamber and comprising a vertical portion extending substantially perpendicularly to an adjacent region of a top wall of the chamber and projecting into the chamber and a substantially triangular horizontal portion connected at one corner to the vertical portion, the sum of the length of the shortest distance between said corner connection and the side of the horizontal portion opposite thereto and the length of the part of the vertical portion projecting into the chamber being substantially one half, or an integral multiple of one half, of said wavelength.

In a preferred embodiment the rotary antenna coupling the waveguide to the heating chamber microwave-wise comprises a vertical portion and a horizontal portion, the horizontal portion being shaped as a substantially triangular plane and connected to the vertical portion at a position near an optional apex thereof. The sum of the length of a line perpendicular to the connection between the horizontal and vertical portions and the length of the part of the vertical portion which projects into the heating chamber is approximately one half of the wavelength used or an integral multiple thereof, with the result that a heating load in the heating chamber is subject to dielectric heating with substantial uniformity and good efficiency.

Embodiments of the present invention will now be more particularly described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of first high-frequency heating appliance embodying the invention;

Fig. 2 is a front sectional view of the appliance of Fig. 1;

Fig. 3 is a perspective view of a rotary antenna of the appliance of Figs. 1 and 2;

Fig. 4a is a perspective view of a rotary antenna of a second appliance embodying the invention;

Fig. 4b is a plan view of a horizontal portion of the antenna shown in Fig. 4a; and

Fig. 5 is a plan view of a horizontal portion of a rotary antenna of a third appliance embodying the invention.

Referring now to the drawings and the embodiment of Figs. 1 to 3, in Fig. 1 the reference numeral 1 denotes a high-frequency heating appliance body which includes a heating chamber 2 with a door 3 installed at an opening thereof so that access to the chamber may be freely made available or unavailable. Disposed atop the body 1 are heater plates 4 and for cooking on these plates, operation knobs A5 installed on the front face of the body can be manipulated to control the power settings of corresponding plate heaters 6 shown in Fig. 2. Indicated at 7 are operating knobs B for controlling the output of a heater installed inside the heating chamber 2 and the output of a magnetron 8, which is used as an example of high-frequency oscillator.

Referring now to Fig. 2, numeral 9 indicates a plate made of heat-resisting dielectric material which is disposed over the plate heaters 6. Indicated at 10 is a heater disposed in an overhead position within the heating chamber 2, while a heater 11 is disposed externally and at the bottom of the chamber 2. By means of these heaters 10, 11, the chamber 2 can be heated with good efficiency. Numeral 12 denotes a heat insulation disposed around a wall 13 of the chamber. Indicated by 14 is a tapered waveguide which propagates the high-frequency output of the magnetron into the chamber 2. The numeral 15 denotes a rotary antenna extending through the waveguide 14 and a top wall 16 of the chamber 2 and in contiguity with the chamber, and consisting of a

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

vertical portion 17 substantially perpendicular to the wall 16 and a horizontal portion 18 which is substantially horizontal. The antenna 15 is driven by a motor 23 through a drive shaft 19, a belt 20 and pulleys 21 and 22.

Fig. 3 is a perspective view of the rotary antenna 15 by itself.

The portion 18 of the rotary antenna 15 is so configured as to have substantially the shape of a sector with an optional angle within the range of 60 to 180°. Moreover, the sum of the radius of the fan-shaped portion 18 and the length of the vertical portion 17 extending into the chamber 2 is approximately one half of the wavelength used or an integral multiple thereof, and the dimensional ratio of the radius of the portion 18 to the length of the portion 17 projecting into the chamber 2 is 2 to 1. The two ends of a fan-constituting arc of the portion 18 are each provided with a projection 24. The free end of each projection 24 is substantially at right angles to the radial edge of the fan-shaped portion and the width of the projection is approximately 1/6 of the wavelength. The length of each projection 24 is not greater than approximately 1/15 of the wavelength.

The function and effect of the above-described construction are explained below.

In order than the rotary antenna 15 may display its effect of rotation, it is important to provide an increased proportion of energy radiation from the horizontal portion 18. If the sectorial angle of the portion 18 is less than 60°, the amount of energy radiated in the horizontal direction is too small. On the other hand, if the angle is greater than 180°, there will be generated areas where electromagnetic waves are cancelled by each other to cause a reverse effect. However, as the sectorial angle of the horizontal segment 18 is set within the range of 60° to 180°, even a single rotary antenna can generate radiant, equivalent horizontal electric fields in a plurality of directions, so that the intensity of the horizontal electric field is increased and the amount of energy radiation from the horizontal portion is increased.

As already mentioned, the sum of the length of the portion 17 and the dimension of the portion 18 inside the heating chamber 2 is set at ½ of the wavelength used or an integral multiple thereof. Because of this, the elctromagnetic waves of half wavelength and longer can be excited without distortion from the waveguide 14 to the antenna 15 and, moreover, the distribution of electromagnetic energy from the antenna 15 in the chamber can be effected with improved efficiency. Furthermore, because the dimensional ratio of the portion 17 to the portion 18 within the chamber 2 is set at approximately one to two, the proportion of energy radiation from the portion 18 can be further increased, this increase being additional to the above-mentioned effect attributable to the fan-like configuration. It was experimentally confirmed that the heating in the central region of the heating chamber can be substantially intensified.

The provision of projections 24 at the ends of the arc constituting the fan-shaped portion provides a certain degree of local concentration of the electric field and as this strong electric field area is rotated, the effect of the antenna 15 is further improved and the uniformity of heating in the central zone of the heating chamber is enhanced. Since the electromagnetic radiation is absorbed from the external region into the core region of the food, a uniform heating is ensured when the electric field distribution in the central zone is greater than in the surrounding zone. However, if the projections 24 are too long, the electric field distribution in the central zone will tend to be somewhat attenuated. It was experimentally found that the best result is obtained when the length of each of the projections 24 is not greater than 1/15 of the wavelength used and the width thereof is approximately one sixth of the wavelength.

Fig. 4a is a perspective view of another form of the rotary antenna 15. The horizontal portion 18 of this antenna 15 has the configuration of a triangular plane and is connected to the vertical portion 17 of the antenna in the vicinity of one of its apices. The sum of the length L of a line perpendicular to the side thereof opposite to the particular apex and the part of the vertical portion 17 projecting into the chamber 2 is equal to approximately one half of the wavelength used or an integral multiple thereof, and the dimensional ratio of the line L to the length of said part of the portion 17 is 2 to 1. Indicated at 24 are projections disposed at ends of the side of the triangle opposite to the apex at which the portion 17 is connected. The width of each projection 24 is not greater than about one fifteenth of the wavelength used.

The function and effect of the above construction will now be explained below. In order that the rotary antenna 15 radiating high-frequency energy may display its effect, it is important to ensure an increased proportion of energy radiation from the horizontal portion 18. Since the portion 18 is shaped as a triangle in this embodiment, the antenna, despite the fact that it is a single one, is capable of generating radiant, unhomogeneous horizontal electric fields in a plurality of directions so as to intensify the horizontal electric field and increase the amount of energy radiation from the portion 18.

Fig. 5 shows yet another form of the horizontal portion 18 of the antenna 15, the portion 18 being shaped as a non-equilateral triangle. This construction provides effects similar to those obtained in the preceding embodiments.

It will be apparent from the above description that with a high-frequency heating appliance embodying this invention, the high-frequency energy supplied from the oscillator through the waveguide can be radiated in good balance from the vertical and horizontal portions of a rotary antenna into the heating chamber so that the elctric field characteristic in the central zone of the heating chamber, where uneven heating would otherwise occur, is improved and the heating load can be substantially uniformly heated.

CLAIMS

1. A high-frequency heating appliance comprising a heating chamber, a waveguide for feeding high-frequency energy of a given wavelength from a high-frequency oscillator to the chamber, and a rotary antenna operable to radiate such energy in the chamber and comprising a vertical portion extending

substantially perpendicularly to an adjacent region of a top wall of the chamber and projecting into the chamber and a substantially triangular horizontal portion connected at one corner thereof to the vertical portion, the sum of the length of the shortest distance between said corner connection and the side of the horizontal portion opposite thereto and the length of the part of the vertical portion projecting into the chamber being substantially one half, or an integral multiple of one half, of said wavelength.

2. An appliance as claimed in claim 1, wherein the ratio of the length of said distance to the length of said part is 2 to 1.

3. An appliance as claimed in claim 1, wherein the horizontal portion is substantially fan-shaped and has a sectorial angle in the range of 60 to 180°.

4. An appliance as claimed in claim 3, wherein the ratio of the length of the radius of the fan-shape and the length of said part is 2 to 1.

5. An appliance as claimed in any one of the preceding claims, wherein the horizontal portion is provided with a plurality of projections at said side thereof.

6. An appliance as claimed in claim 5, wherein the projections are provided one at each end of said side.

7. An appliance as claimed in either claim 5 or claim 6, wherein each of the projections has a width of substantially 1/6 of said wavelength.

8. An appliance as claimed in any one of claims 5 to 7, wherein each of the projections projects by an amount of at most 1/15 of said wavelength.

9. A high-frequency heating appliance substantially as hereinbefore described with reference to Fig. 3 of the accompanying drawings.

10. A high-frequency heating appliance substantially as hereinbefore described with reference to Figs. 4a and 4b of the accompanying drawings.

11. A high-frequency heating appliance substantially as hereinbefore described with reference to Fig. 5 of the accompanying drawings.

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